

Flight Test of Weather Data Exchange Using the 1090 Extended Squitter (1090ES) and VDL Mode 3 Data Links

ICNS Briefing

April 28, 2004

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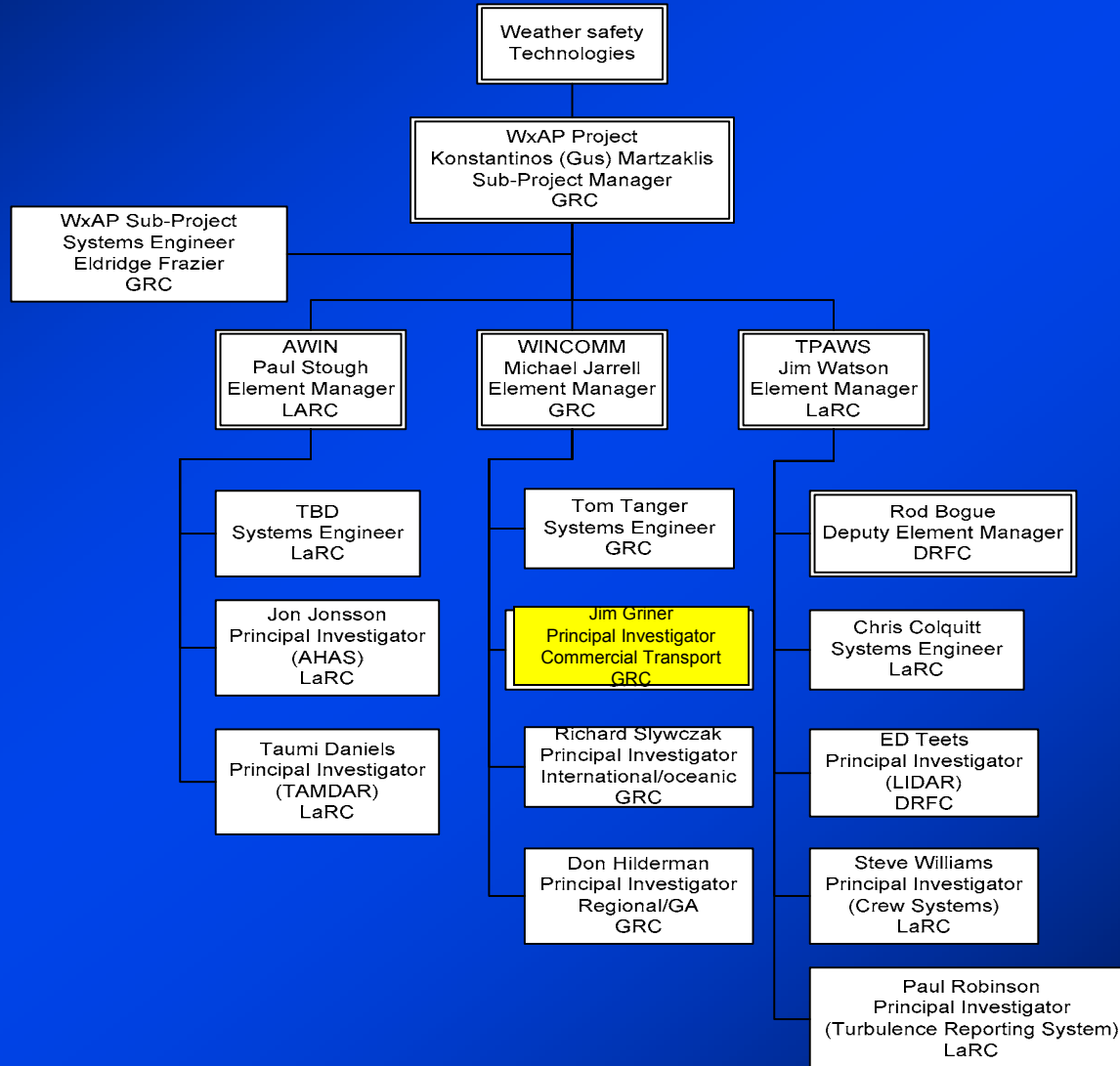
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Organization

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Commercial Transport Goal

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The specific goal of the Commercial Transport task area is to develop a weather dissemination capability for commercial transport aircraft within a national network that includes:

- Transmission of on-board sensed turbulence information to ground users and between aircraft.
- Broadcast graphical weather products to the pilot.

Architecture Design

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- Due to the near-term focus of the WINCOMM project it was necessary to select datalinks that already reside on commercial transport aircraft or were on a path for installation in the near future.
- No single datalink can currently satisfy the project requirements for air-to-air, ground-to-air broadcast, and air-to-ground two-way communication to this class of aircraft. It was therefore necessary to design a hybrid communication architecture to meet the project objectives

Objectives

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Demonstrate a path to implementation for the following value added objectives:

- Dissemination of data from own ship turbulence events to other aircraft and ground users.
- Receive, process and deliver valid turbulence warnings to the cockpit from other equipped aircraft.
- Receive and display Flight Information Service Broadcast (FIS-B) ground-air weather products.

Objectives 1&2

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- Dissemination of data from own ship turbulence events to other aircraft and ground users.
- Receive, process and deliver valid turbulence warnings to the cockpit from other equipped aircraft.

Need an Air-to-Air link

Air-to-Air

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A natural match for air-to-air communication is one of the Automatic Dependent Surveillance Broadcast (ADS-B) links.

- On July 1, 2002, the FAA announced the ADS-B link decision [5], selecting the 1090 Extended Squitter link for air carrier and private/commercial operators of high performance aircraft

1090ES datalink was selected by WINCOMM to fulfill the air-to-air datalink requirements for the transmission of turbulence alerts.

Turbulence Alert Message

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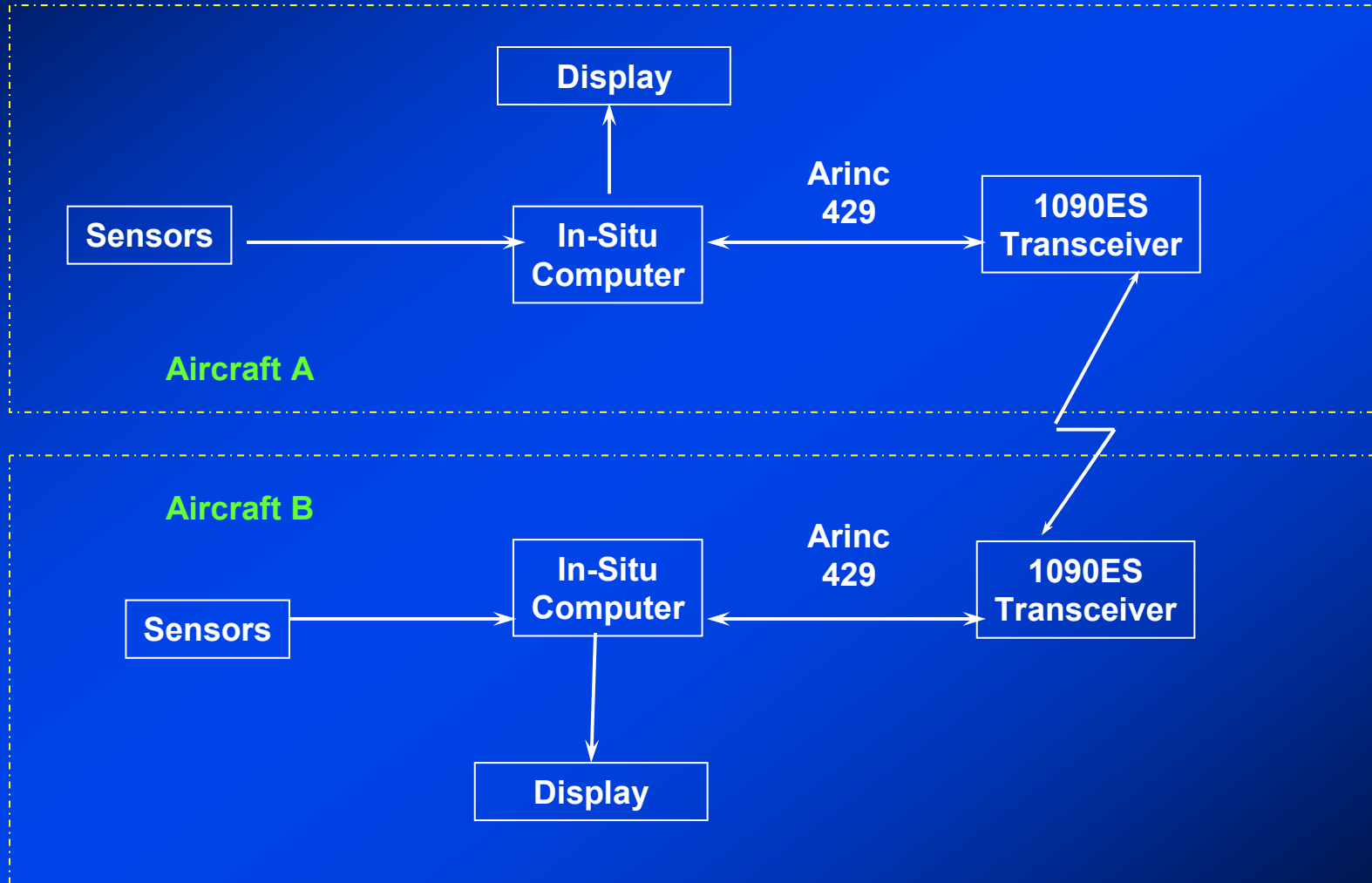


- The turbulence alert message will consist of the following parameters:
 1. Time
 2. Latitude
 3. Longitude
 4. Altitude
 5. Processed Normal Load
 6. Processed Aircraft Constant
- Standard ADS-B messages already contain the first four parameters, it is only necessary to broadcast two additional parameters. These two additional parameters are each eight bits long, totaling an additional 16 bits to be transmitted. The additional parameters will be formatted as a payload to a standard ADS-B message, in compliance with DO-260A.

1090ES Data Flow

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Lab Testing in General

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- Laboratory testing of the datalinks will concentrate on the implementation of the additional messages transmitted and the associated equipment software modifications.
- Limited testing will be conducted on the existing radio/transceiver operation.
- Extensive testing of the datalinks have been completed by the FAA, which does not bear repeating.

1090ES Lab Testing

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- Two complete sets of 1090ES equipment, representing two aircraft, will be tested back-to-back using appropriate attenuation.
- A pre-recorded data file will be used to simulate inputs to the In-Situ computer, in order to exercise the turbulence algorithms.
- Data files will be collected on both aircraft racks to verify transmission and reception of turbulence alert messages.
- Limited attenuation profiles will be utilized to represent the experimental flight campaign.

1090ES Lab Testing

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- Traffic on 1090MHz, beyond the ADS-B message emanating from the two aircraft, will not be emulated during testing.
- The ability to transmit the additional turbulence alert ADS-B messages at 1090MHz has been shown to work in simulation, and will not be tested with other traffic until flight tests are conducted.

1090ES Flight Testing

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- Flights will be conducted in a convenient area of the continental U.S., as determined by the spectrum approval of the FAA.
- No turbulence encounters will be sought out. Turbulence alert test messages will be transmitted in order to effectively utilize flight time.
- The flights will consist of flying two aircraft at various ranges in order to perform limited testing of effective reception of turbulence alert messages.
- Data files will be collected on both aircraft racks to verify transmission and reception of turbulence alert messages.

Objective 1&3

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- Dissemination of data from own ship turbulence events to other aircraft **and ground users.**
- **Receive and display Flight Information Service Broadcast (FIS-B) ground-air weather products.**
- This objective requires at a minimum a ground-to-air broadcast link. WINCOMM's experiments will also include an air-to-ground request message, in order to facilitate the broadcast of additional value-added weather products, and a reliable air-ground turbulence alert message.
- With the additional requirements we now need a *bi-directional air-to ground datalink.*

Bi-Directional Air-Ground link

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The two bi-directional datalinks on the horizon for near-term use are VDL Mode 2 and VDL Mode 3.

- VDL Mode 3 uses a Time Division Multiple Access (TDMA) scheme, which allows a number of users to access a single Radio Frequency (RF) channel by dividing a 25 kHz channel into four time slots and allocating each time slot to one user/application. The channel separation can be utilized to effectively separate non-critical data, weather information, from critical data, Controller Pilot DataLink Communication (CPDLC).
- VDL Mode 3 was designed with a ground broadcast mode, which will facilitate FIS-B communications.

VDL Mode 3 Messages

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- Reliable Air-ground turbulence messages
- Reliable Air-ground message for requesting additional graphical weather products
- Broadcast Ground-Air FIS-B weather products

Air-Ground Turbulence Message

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- The turbulence message will consist of the following parameters:
 1. Time
 2. Latitude
 3. Longitude
 4. Altitude
 5. Aircraft Weight
 6. Airspeed
 7. Mach Number
 8. Processed Normal Load
 9. Processed Aircraft Constant
- Additional parameters are required beyond those in the turbulence alert message, to allow ground processing of the downlinked messages to be assimilated into weather prediction models and a future national turbulence weather product.

Air-Ground Request Message

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- In order to allow pilots to request graphical weather products which may not be part of the standard weather product set, a request message will be transmitted to schedule the uplink of the desired product.
- The final format of this message has not been defined.

Ground-Air Weather Products

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- For the purposes of the WINCOMM project, the broadcast FIS-B messages will, at a minimum, consist of the following weather products:

1. Text Products

- METARs
- TAFs
- PIREPs
- AIRMETs
- SIGMETs
- Convective SIGMETs
- Alert Weather Watches

2. National NEXRAD

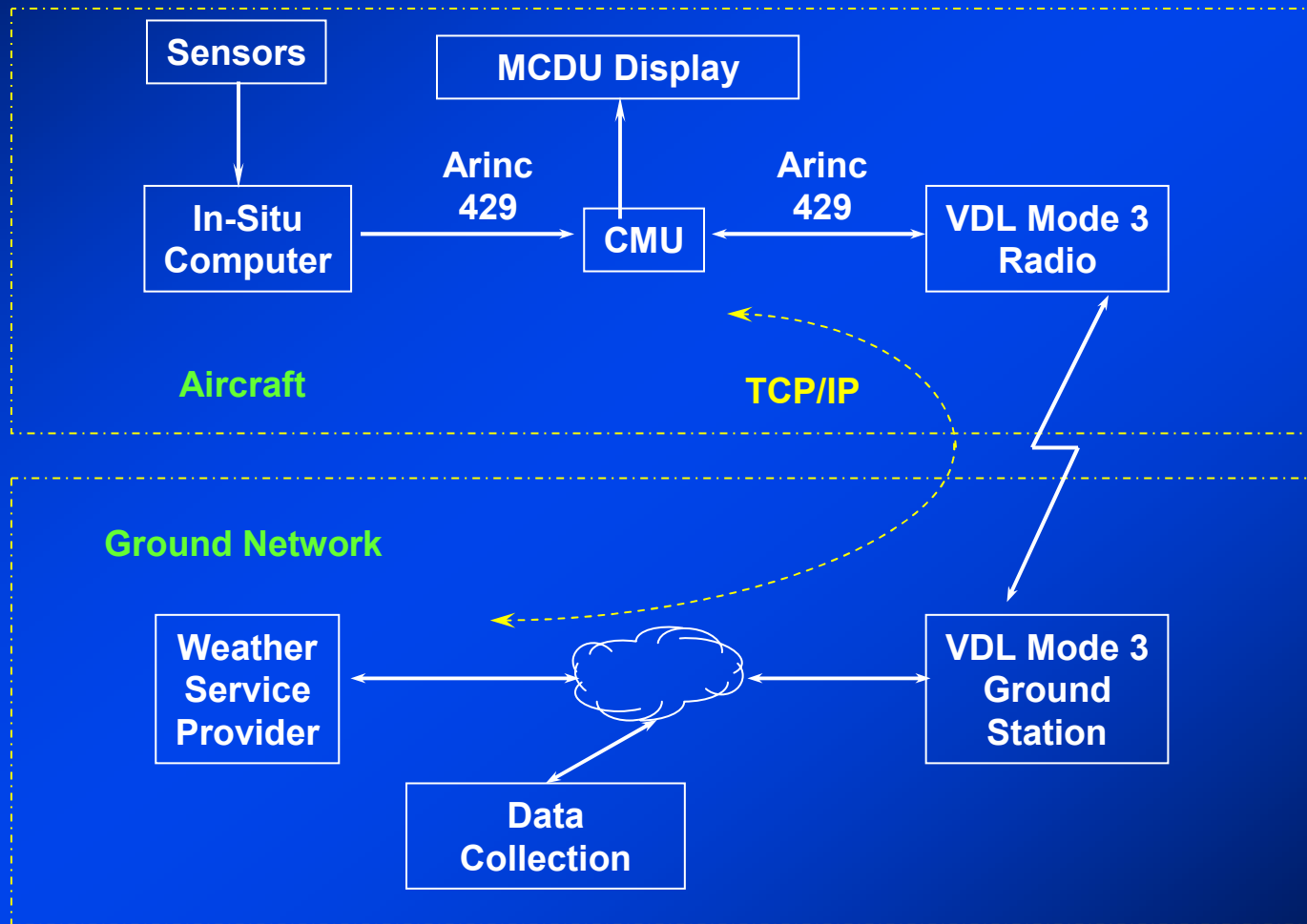
3. Graphical AIRMETs
4. Graphical SIGMETs
5. Graphical Convective SIGMETs
6. Graphical Alert Weather Watches
7. Graphical METARs

- In addition to these standard products, the pilot requested messages will be transmitted as requested and as the channel is available

VDL Mode 3 Data Flow

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VDL Mode 3 Lab Testing

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- One set of VDL Mode 3 avionics will be tested against an FAA ground station. This will either be through an attenuation scheme similar to the 1090ES laboratory testing, or through an antenna-based method.
- A pre-recorded data file will be used to simulate inputs to the In-Situ computer, in order to exercise the turbulence algorithms.
- A group of pre-generated FIS-B weather products will be used to feed the ground station, during testing. This group of products will include both standard broadcast messages as well as pilot requested messages.
- Data files will be collected on both sides to determine message transmission and reception.

VDL Mode 3 Flight Testing

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- Flights will be conducted in an area near an FAA VDL Mode 3 ground station.
- No turbulence encounters will be sought out.
- Turbulence alert test messages will be transmitted in order to effectively utilize flight time.
- Pilot weather product request messages will be transmitted from the aircraft.
- Standard FIS-B as well as pilot requested weather products will be broadcast to the aircraft.

VDL Mode 3 Flight Testing

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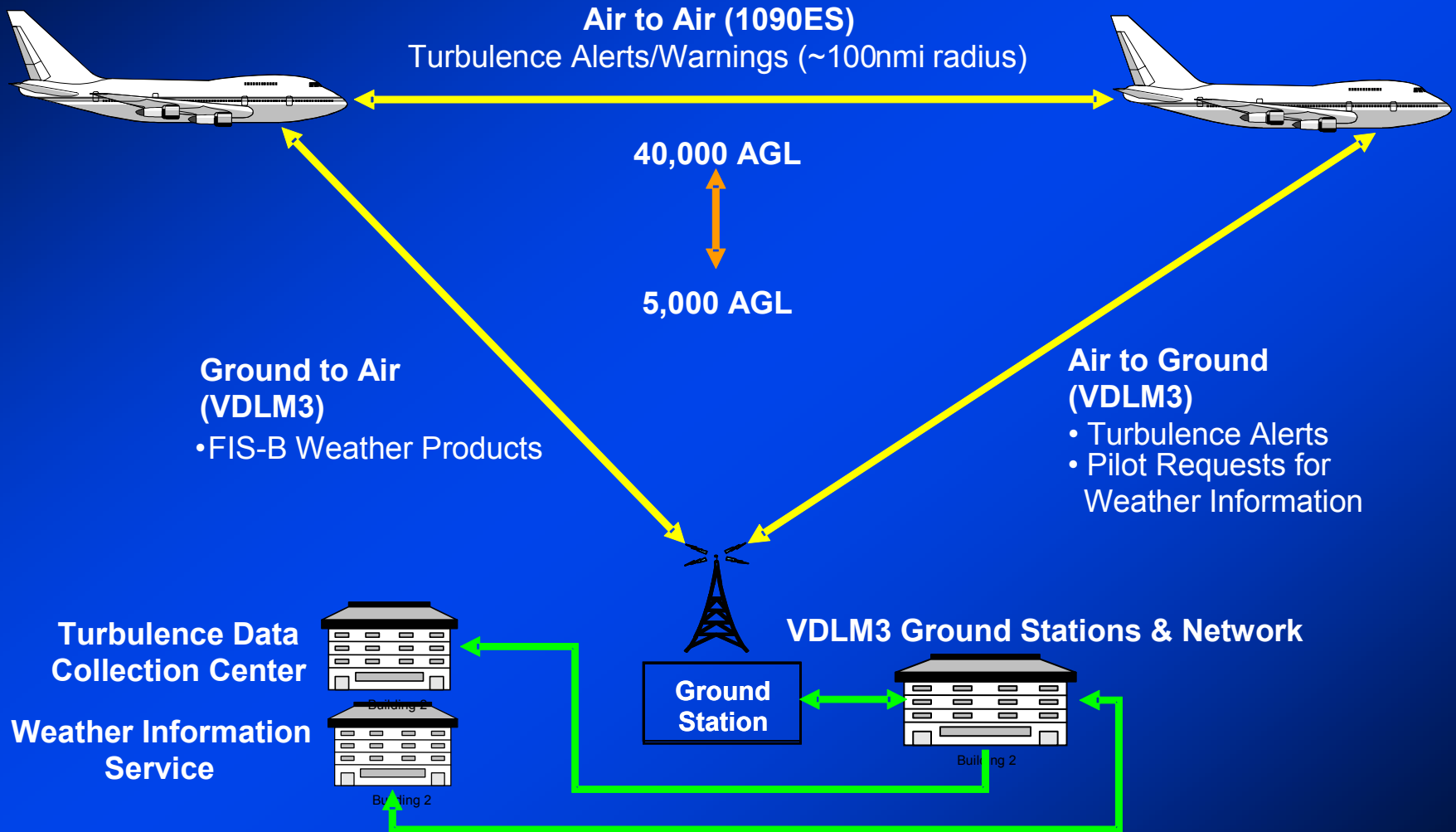


- The flights will consist of flying one aircraft at various ranges and altitudes from the ground station in order to perform limited testing of effective reception of turbulence downlink and FIS-B messages.
- Data files will be collected on both sides to determine message transmission and reception.

Overall Architecture

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Summary

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- All equipment modifications will be software based in order to allow the reception and transmission of these additional messages.
- All modifications will be made within the accepted standards or in a manner consistent with the standards.
- These changes are being worked closely with industry partners with a path toward certification.